A ROBOTICS SUCCESS: Cleaning Tanks at the Oak Ridge National Laboratory

The Problem: The Gunite and Associated Tanks (GAAT) are located at the Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee. Constructed in the early 1940s, the tanks were used to collect, neutralize, store, and transfer liquid radioactive and/or hazardous waste. Prior to remediation, these tanks contained the largest inventory of underground contaminants in the main ORNL plant area and were identified as a high priority for clean up. The goal of the remediation project was to remove the waste and stabilize the tanks in order to protect workers, the public, and the environment.

The Technology: The Modified Light-Duty Utility Arm (MLDUA) was designed and built by Spar Aerospace, Ltd., with technical direction from the Tanks Focus Area (TFA) and the Robotics Crosscutting Program (Rbx). The MLDUA was delivered to ORNL in November 1996 and was immediately integrated with the waste dislodging and conveyance equipment and Houdini vehicle system for cold testing. The MLDUA is one of four Light-Duty Utility Arm (LDUA) systems that were developed as part of a collaboration involving five U. S. Department of Energy (DOE) sites. A truck-mounted LDUA system that was delivered to the Hanford Site was deployed for tank inspection, and a skid-mounted version that was delivered to Idaho National Engineering and Environmental Laboratory has been deployed in several tanks for sampling and inspection. The MLDUA has a longer reach and higher payload capability than the three other LDUA systems.

The Houdini robotic vehicle was designed and built by RedZone Robotics, Inc., for the Rbx. It was designed to provide a high-capacity, versatile, remotely operated work platform that would fit through existing tank riser penetrations. The Houdini vehicle includes two on-board video cameras, a Schilling Titan-III servomanipulator, and a plow blade. The vehicle can fold up, allowing it to fit though the 24-in.-diameter risers that permit access to the gunite tanks. Inside the tank, the vehicle opens up to a 4- x 5-ft platform that can be operated as a thousand-pound miniature bulldozer or as a general-purpose mobile manipulator for operation of various in-tank tools.

The Deployment: Tank waste retrieval operations began in June 1997 and were completed in September 2000. Several remote technologies have been integrated and implemented to remove wastes from GAAT.

An advanced waste removal technology known as confined sluicing was implemented to dislodge and remove sludge from the tanks. The TFA developed this technology that consists of a “vacuum cleaner” type head, or end effector, which uses three rotating, high-pressure water jets to loosen sludge from the tank bottoms. At the bottom of the end effector is the suction intake for a jet pump that is located in the mast of a four degree-of-freedom hose management arm. This arm doubles as a positioning device and as the pipeline to transfer waste slurries out of the tanks. The confined sluicing end effector is attached by hose to the end of the hose management arm. A similar end effector was used for high-pressure cleaning of tank walls.

The confined sluicing end effector and gunite scarifying end effector were moved around inside the tanks by two remotely operated systems. The primary end effector positioning system was a large eight-degree-of-freedom robotic arm called the MLDUA. A remotely operated vehicle system called the Houdini was also used for tool positioning in the tanks. Overview cameras in the tanks and cameras located on the robotic arm and vehicle provided equipment operator views of the tank interiors and waste removal activities.

The Benefit: Implementation of these remote systems resulted in significant cost and schedule savings. The GAAT Remediation Project completed waste removal operations in September 2000, approximately 13 years ahead of original schedule estimates and $121 million under initial cost estimates. Eight tanks have been cleaned and await stabilization with grout. Closure operations are planned to be completed by the end of FY 2001. More than 600,000 gallons of waste slurry was removed from these eight tanks, including more than 80,000 gallons of sludge heel. A sluicing campaign conducted in the 1980s had removed the waste that was easily mobilized leaving behind a layer of thick sludge that varied from 8 in. to over 3 ft.

Future Advances through Rbx Initiatives

Initiatives: The remote systems deployed at GAAT provided adequate remote functionality and removed workers from the hazardous environment, but with the exception of the MLDUA, these systems were fundamentally teleoperated systems with little or no automated capabilities. The Robotics and Intelligent Machines initiative could provide technology to increase the level of automation within these systems, thereby increasing efficiency and productivity. Coordinated motion of multiple cooperating robots of different designs is needed to improve waste retrieval efficiencies. Using project planning that incorporates deployment of advanced controls technologies expedites task completion, especially on terrain with minimal distinguishing features. Operators could then focus on autonomous operation of the Houdini vehicle. Supervisory control would allow a single operator to manage a team of robots, such as the MLDUA and Houdini, reducing the need for multiple operators.

Containment Structures for the Remote Retrieval Systems

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